QUANTUM NEMATOGENS AND THE ELECTRONIC ANISOTROPY OF THE IRON BASED SUPERCONDUCTOR $Ca(Co_xFe_{1-x})_2As_2$

M. P. Allan[1,2*] & T.-M. Chuang,[1,3*] Yang Xie,[1] Jinho Lee,[1,4] Ni Ni,[5,6] S. L. Bud'ko,[5,6] G. S. Boebinger,[3] Q. Wang[7], D. S. Dessau[7], P.C. Canfield,[5,6] J. C. Davis[1,2,4,8]

[1]Laboratory of Atomic and Solid State Physics, Department of Physics, Cornell University, Ithaca, NY 14853, USA; [2]School of Physics and Astronomy, University of Saint Andrews, Saint Andrews, Fife KY16 9SS, UK; [3]National High Magnetic Field Laboratory, Department of Physics, Florida State University, Tallahassee, FL 32310, USA; [4]Condensed Matter Physics and Materials Science Department, Brookhaven National Laboratory, Upton, NY 11973, USA; [5]Ames Laboratory, U.S. Department of Energy (DOE), Iowa State University, Ames, IA 50011, USA; [6]Department of Physics and Astronomy, Iowa State University, Ames, IA 50011, USA; [8]Department of Physics and Astronomy, University of British Columbia, Vancouver, British Columbia, Canada.

The phase diagram of the superconducting iron-pnictides includes two lines of magnetic and structural phase transitions whose temperatures are suppressed upon doping [1]. At or around the point where the transition temperatures approach zero, a dome of superconductivity exists. In the 122 family of iron-pnictides, nematic transport has been discovered in the magnetic phase [2,3], and intriguingly, the effect is very weak at zero doping and reaches a maximum at dopings right before superconductivity appears. This cannot be explained by the small orthorhombic lattice distortion. Furthermore, at the same location in the phase diagram of the 1111 family, nanoscale spatial charge arrangements were reported [4]. Thus the question arises as to what electronic structure can lead to these unusual properties.

We investigate the electronic structure of the iron-pnictide $Ca(Co_xFe_{1-x})_2As_2$ in the discussed doping range using spectroscopic-imaging scanning tunneling spectroscopy (SI-STM). In the local density of states, static, unidirectional, electronic nanostructures are visible. We identify them as randomly scattered electronic nematogens that are aligned along one Fe-Fe axis only [5,6]. The autocorrelation shows a triple-peak with the same C_2 symmetry. This clear triple-peak shape gives more information about the nematic electronic structure: First, it reveals that the characteristic size of the nematogens is ~22 Å, which corresponds to ~8 a_{FeFe}, second, it shows that this is the only persistent length of the low-energy electronic structure of $Ca(Co_xFe_{1-x})_2As_2$ and last, it gives strong constraints on the microscopic properties of the nematogens. Each nematogen consists of two conductance-peaks, separated by ~22 Å, and aligned along the same axis. Those dimers are then distributed in a non-periodic, 'glassy' way. The measured Fourier-transform, autocorrelation, and conductance maps agree well with this proposal. We emphasize that this is the first time electronic nematogens have been reported. SI-STM can also detect dispersive **k**-states via quasiparticle-interference. In $Ca(Co_xFe_{1-x})_2As_2$, these exhibit a one-dimensional dispersion. We explain this with our nematogen proposal and relate it to the transport anisotropy in the 122 iron-pnictides.

[1] N. Ni *et al.*, Phys. Rev. B **78**, 014523 (2008).
[2] M. A. Tanatar *et al.*, Phys. Rev. B **81**, 184508 (2010).
[3] J.-H. Chu *et al*, Science **329**, 824 (2010).
[4] G. Lang *et al.,* Phys. Rev. Lett. **104**, 097001 (2010)
[5] T.-M. Chuang & M.P. Allan *et al.*, Science **327**, 181 (2010).
[6] M.P. Allan & T.-M. Chuang *et al.*, 2010.

*These authors contributed equally to this work.